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Study and Simulation the Phenomenon of a Heat Pump in a Heating Installation

Didi Faouzi [1]*, N. Bibi-Triki [2]
[1]* Faculty of Science and Technology, Department of Physics, University of Abou-bakr Belkaïd, B.P. 119, Tlemcen, Algeria
[2] Materials and Renewable Energy Research Unit M.R.E.R.U University of Abou-bakr Belkaïd, B.P. 119, Tlemcen, Algeria
E-mails : [1]* didifouzi19@yahoo.com , [2] n_bibitriki@hotmail.fr

Abstract :This article is a study of the characteristics of a centrifugal pump in heating a building. For the fact is a program for controlling operation of the pump with maximum efficiency and minimum useful energy, we obtain graphs of variation of these characteristics.

Keywords: Centrifugal pump, Heating, pressure, Temperature, Performance .

I. INTRODUCTION

It is commonly said that a heating system's role in maintaining all local winter stay where human beings at a given temperature. We should say more accurately it is to compensate for heat loss of the body hanging breathed the cold season warming the environment to achieve a balance between heat production and loss, and ensure the physical well-being of the human.

Much of the total primary energy consumption is used for heating purposes with the rest a weak performance times. The awareness of the fact that large energy source is not renewable and that in addition their use contributes to the deterioration of our environment also conducted in recent years to take numerous measures to save this energy and more specifically in the field of heating. It is therefore now particularly characterized in that in order to reduce energy consumption, it was necessary to take many arrangements, some long-term, both as regards the buildings themselves as item view innovation different thermal material intended to equip.

Among the equipment used centrifugal pump so you have to do a study to minimize the energy consumed by the pump and increased performance. The experimental work was carried out on a centrifugal pump, the machine is equipped with a low specific speed wheel followed by a diffuser and volute Aube circular section, mainly determining the critical flow suction recirculation input and the output of the wheel. And the temperature of grafted and the total nominal output and efficiency.

As such, our study is in this context, namely the pumps in a heating system. This equipment is if you do beware become very energy intensive, unsuitable they make a lot of noise and do not meet the requirements necessary pressure.

II. Physical culture

II.1. Forecast

Any heating or air conditioning is characterized by the transfer of fluids from one spot to another, as it is water (eg in a hot water heating or ice between an evaporator and a cooling coil) flowing in a pipe or air flowing through a conduit.

In most of these pipes and these pipes we are dealing with a continuous medium that present the same physical characteristic in wholes directions (called isotropic medium) and which, moreover, is highly deformable, adapting to the the geometric shape of the container. Whether liquid or gaseous fluid called any medium of this type, the laws of balance or movement to which it is subject constituting the fluid mechanics.

Permanently confronted with various flows, HVAC specialist should therefore know the main properties of fluids, to be familiar with the phenomena accompanying any flow, knowledge flow measure and calculate losses. So these different aspects of fluid mechanics which we explain below. [4]

II.2. Equation of conservation of energy

II.2.1. Theorem Bernoulli

n is a perfect fluid mass (stationary flow isovolume, no friction) between sections and dS1 dS2 at time t (drawings below); at time t + dt, m is between dS1 'and dS2'**.**

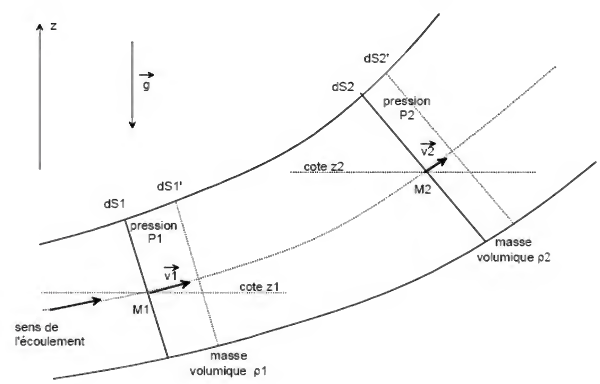

Fig.1 Diagram of steady flow iso volume

By applying the conservation of energy applied to the mass m between times t and t + dt, we show that one can write:

$$\rho\frac{v_2^2}{2}+\rho g z_2+p_2=\rho\frac{v_1^2}{2}+\rho g z_1+p_1=Cte \quad (1)$$

Or again:

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$$\rho \frac{v^2}{2} + \rho g z + p = Cte \quad (2)$$

$p \equiv [bar, atm, Pa]$: Pressure .

$\rho \equiv [kg/m^3]$: Density of the fluid .

$z \equiv [m]$: Standing height or coast.

$\boldsymbol{v} \equiv [m/s]$: The fluid velocity.

Work volume forces (weight) and surface forces (pressure) :

- ✓ p **is the static pressure.**
- ✓ $\rho g z$ **is gravity pressure.**
- ✓ $\rho \frac{V^2}{2}$ **is the kinetic pressure.**

Dividing all the terms of the above equation by the product ρg, we write all terms in the dimension of height (in meters pressure fluid column).

$$\frac{v^2}{2g} + z + \frac{p}{\rho g} = H_T = Cte \quad (3)$$

H_T : Total Heigh (m) .

$\frac{p}{\rho g}$: Pressure height.

$\frac{v^2}{2g}$: Dynamic height.

z : Height position or coast.

$z + \frac{p}{\rho g}$: Height piezometric.

If a flow (1) → (2) without exchange of work

When in a flow of a perfect fluid, there is no machine (or pump or turbine) between points (1) and (2) of the same power line, the Bernoulli relationship can be written in one or more of the following forms:

$$\frac{1}{2}\rho(\boldsymbol{v}_2^2 - \boldsymbol{v}_1^2) + \rho g(z_2 - z_1) + (p_2 - p_1) = 0 \quad (4)$$

Where :

$$\frac{1}{2g}(\boldsymbol{v}_2^2 - \boldsymbol{v}_1^2) + (z_2 - z_1) + \frac{(p_2 - p_1)}{\rho g} = 0 \quad (5)$$

II.2.2. Relationship Bernoulli widespread

- ✓ **Case of a flow (1) → (2) with energy exchange :**

If the frictional forces involved (P_f power dissipation <0) or when the fluid passes through a hydraulic machine, it exchanges energy with this machine: the power P is exchanged:

$$\frac{1}{2g}(\boldsymbol{v}_2^2 - \boldsymbol{v}_1^2) + (z_2 - z_1) + \frac{(p_2 - p_1)}{\rho g} = \frac{P}{\rho g q_V} \quad (6)$$

- ✓ $P > 0$: If power is received by the fluid (eg. PG pump).
- ✓ $P < 0$: If power is supplied by the fluid (eg. PR turbine).

$$\left(\rho \frac{v_2^2}{2} + \rho g z_2 + p_2\right) - \left(\rho \frac{v_1^2}{2} + \rho g z_1 + p_1\right) = \frac{P_f + P_R + P_G}{q_V} \quad (7)$$

- ✓ **Case If a pump:**

$$\frac{1}{2g}(\boldsymbol{v}_2^2 - \boldsymbol{v}_1^2) + (z_2 - z_1) + \frac{(p_2 - p_1)}{\rho g} = \frac{P}{\rho g q_V} \quad (8)$$

For a pump called net height or height gauge the magnitude H given by:

$$H = \frac{P}{\rho g q_V} \quad \text{or} \quad H = \frac{P}{g q_m} \quad (9)$$

q_V : Is the volume flow m$^{3/}$s .

q_m : Is the mass flow kg/s .

II.3. Pitot tube

To calculate the velocity in the pipe:

Identical start and end points (B and A) but via two paths (1) and (2) different:

- ➢ **Dynamic (Bernoulli) :**

$$\frac{1}{2}\rho_1 \boldsymbol{v}_A^2 + \rho_1 g z_A + p_A = \rho_1 g z_B + p_B \quad (10)$$

$$\Rightarrow p_B - p_A = \frac{1}{2}\rho_1 \boldsymbol{v}_A^2 + \rho_1 g z_A - \rho_1 g z_B = \frac{1}{2}\rho_1 \boldsymbol{v}_A^2 + \rho_1 g(z_A - z_B) \quad (11)$$

- ➢ **Static (the fundamental or Bernoulli with $\boldsymbol{v_B} = 0$:**

$$\frac{1}{2}\rho_1 \boldsymbol{v}_A^2 = \rho_1 g(z_D - z_C) + \rho_2 g(z_C - z_D) = -\rho_1 g z + \rho_2 g z = g z(\rho_2 - \rho_1) \quad (12)$$

$$\Rightarrow \boldsymbol{v}_A = \sqrt{2gz\frac{(\rho_2 - \rho_1)}{\rho_1}} \quad (13)$$

If $\rho_2 >> \rho_1$ (liquide 2 selected accordingly).

II.4. State equations

The equations governing the flow of a Newtonian fluid is the continuity equation. [1]

$$\frac{\partial \rho}{\partial t} + div(\rho \vec{v}) = 0 \quad (14)$$

The momentum conservation equation, called Navier -Stokes:

$$\frac{\partial \vec{v}}{\partial t} + \vec{\boldsymbol{v}}.\overrightarrow{grad}(\boldsymbol{v}) = -\frac{1}{\rho}\overrightarrow{grad}(p) + \vec{g} + \nu\Delta\vec{\boldsymbol{v}} \quad (15)$$

III. Installation and performance model results

III.1. Technology area

The algorithm for determining the power consumption and the liquid exit temperature for a given volume flow and fluid inlet conditions. The model takes into account the use of three types of pumps in heating and cooling buildings:

- ✓ constant flow pumps, where flow regulation is carried downstream by a three-way valve;
- ✓ constant flow downstream pumps without regulation;
- ✓ the speed drive pumps.

The model was designed for use oriented calculation of consumption of heating and air conditioning in which information about the hydraulic balance of the plant are not known.

In the case of the pump with a variable speed motor, consumption is determined as consumption under partial load function of variable flow.

The pump is thus characterized by a pressure difference, a volume flow and a consumption pump / motor at nominal conditions. The power demand at part load is determined by an empirical relationship based on a speed ratio at nominal flow rate. The pressure difference generated by the pump in non-nominal conditions is not calculated. The fluid temperature rise is determined for a shaft power, assuming that the engine performance and torque (pump motor) are constant.

The algorithm can determine the entry conditions from the output conditions specifying a negative fluid flow, assuming a negligible change in the density of the fluid in the pump (incompressible fluid model).

The pumps are in a building air conditioning system in the chilled water circuits and hot water and in the water loop of the inverter units water loop. [17]

IV. Algorithms

- ✓ Calculation of total nominal return and the only pump.
- ✓ Determination of the partial load ratio (PLR).
- ✓ Determining the fraction of full power (FFLP) from the empirical relationship.
- ✓ Calculating the power on the pump shaft and the power of the partial load engine.
- ✓ Determining the fluid outlet conditions.

IV. 1. NA FOR ALGORITHM CALCULATED

Table 1: Input Nomenclature for the algorithm calculates

NAME	DESCRIPTION	UNIT	MIN	MAX	FAULT
$\dot{m}_e$	FLUID FLOW	kg/s	0	$+\infty$	
T_e	FLUID INLET TEMPERATURE	°C	-20	100	

Table 2: Outputs of Nomenclature for calculating algorithm

Name	Description	Unit	Min	Max	Fault
T_s	Fluid outlet temperature	°C	-20	100	
$Qloss_{pump}$	Energy transmitted to the fluid	W			
$\dot{W}_p$	Power absorbed by the motor	W	0	$+\infty$	

Table 3: Settings Nomenclature for calculating algorithm

Name	Description	Unit	Min	Max	Fault
η_m	Engine performance	/	0	1	0,95
$f_{m,perte}$	Fraction of the losses of the engine transmitted to the fluid	/	1		0
$q_{v\,nom}$	Nominal volume flow	m^3/s	0	$+\infty$	
$\dot{W}_{p,rat}$	Nominal power	W			
Δp_{rat}	Nominal pressure difference	Pa			
C_i	Regression coefficients of performance at partial loads $FFLP = C0 + C1\,PLR + C2PLR2 + C3PLR3$	/			
c_{pLiq}	Specific heat of the fluid	$J/kg.K$			
ρ_{Liq}	Fluid density	kg/m^3			1000

V. SIMULATION PHENOMENA IN THE PUMP

V.1. PERFORMANCE PUMP ACCORDING TO OVERALL PERFORMANCE

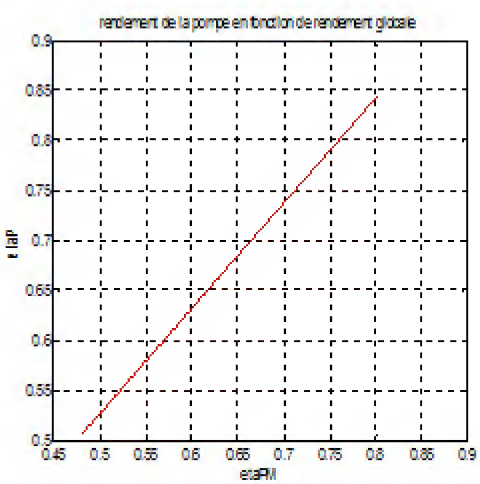

Figure 2. Yield Curve pump overall performance function

V. 2. Transmitted energy for fluid according to engine performance

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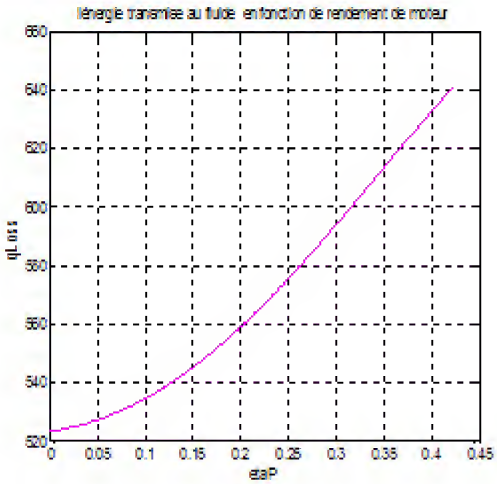

Figure 3. Curve energy transmitted to the fluid in motor output function

V.3. The transmitted energy fluid according to engine power

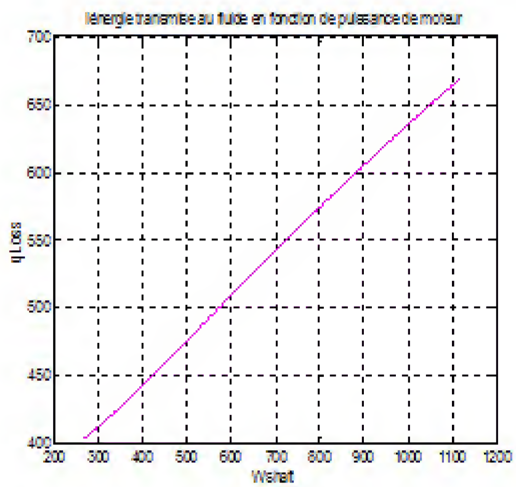

Figure 4. Curve energy transmitted to the fluid in engine power function

V. 4. partial load ratio based on mass flow

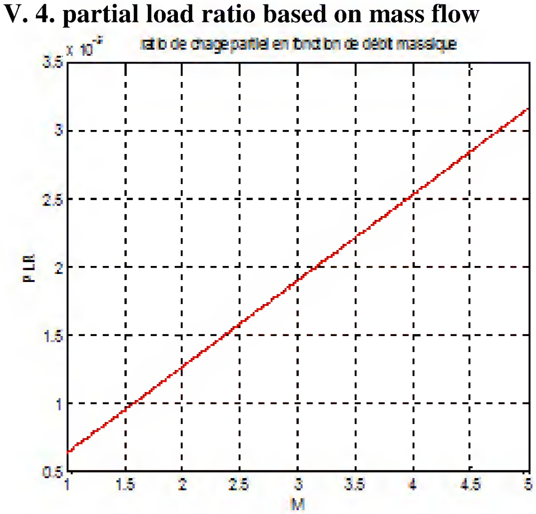

Figure 5. Curve partial load ratio based on mass flow rate

V.5. partial load operation based on nominal volume flow

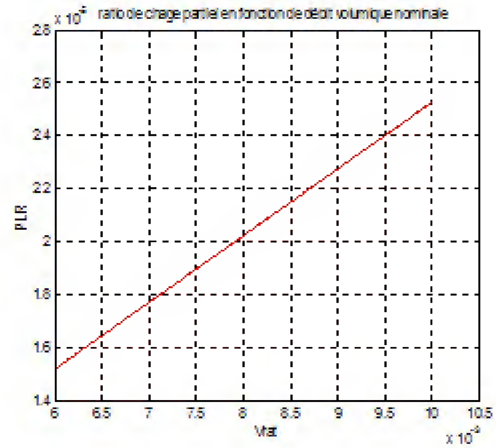

Figure 6. Curve partial load ratio as a function of nominal volume flow

V.6. Fraction of the power at full load depending on partial load ratio

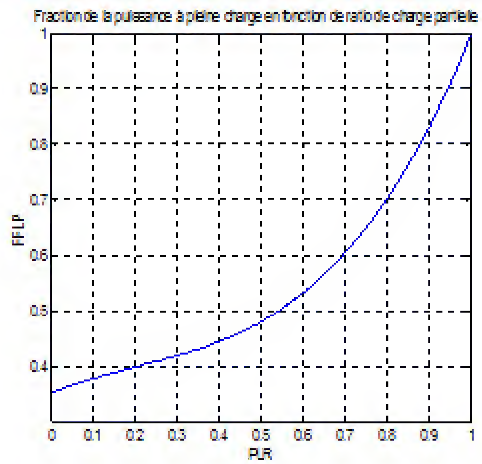

Figure 7. Curve fraction of the power at full load versus part load ratio

V.7. Engine power output function

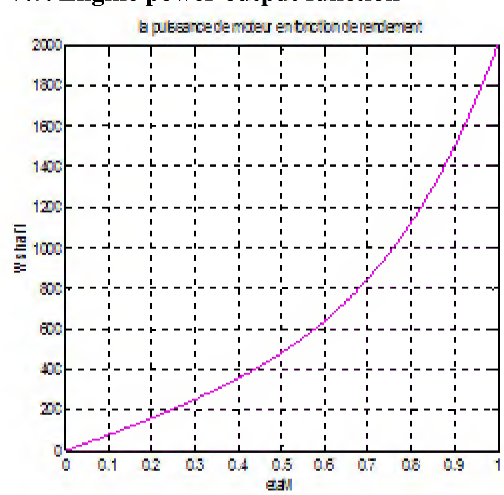

Figure 8. Diagram of engine power output function

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V.8. Pump power based on the power fraction of a full load

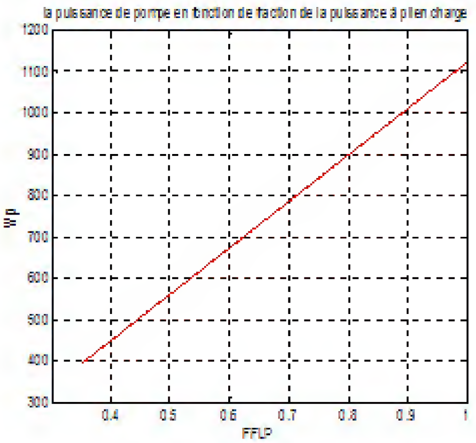

Figure 9. The pump power curve in terms of fraction of the power at full load

V.9. Power pump according to engine power

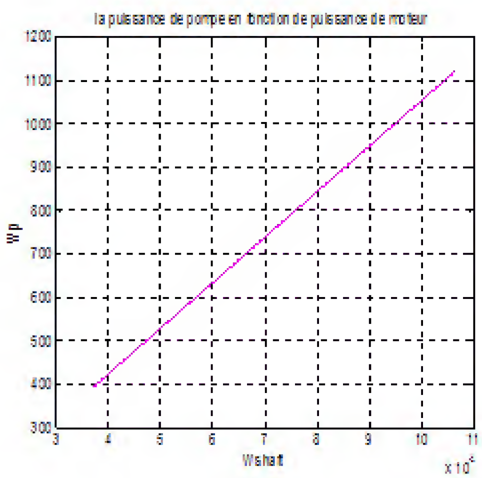

Figure10. Pump power curve in engine power function

V.10. Efficiency of the pump motor output function

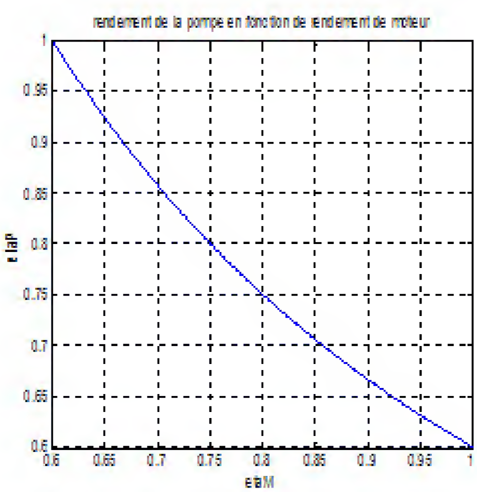

Figure 11. Pump performance curve engine output function

V.11. Temperature output as a function of the inlet temperature

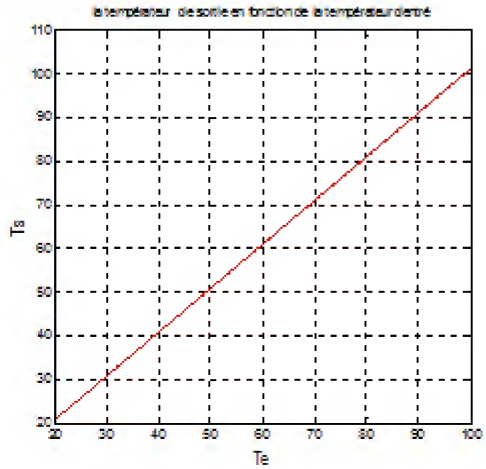

Figure 12. outlet temperature curve entered in temperature function

VI.CONCLUSION:

The pumps are devices which generate a pressure difference between the inlet and outlet pipes. This difference is volume flow function which is adjusted according to our need. We chose centrifugal pumps high flow range. The study is important, given the possibility of effectors settings when working.

In our brief, and after Decree types of pumps as their feature, we focused on heating or cooling applications.

The aspect of using three types of pumps to be unregulated swallows the other with regulation and the last with speed control, offers a choice of adequate control

We show in this project that charge considerably changes with the mass flow rate and all other features such as power are influenced by the flow variation

This project requires a deepening to evaluate the use of a given pump and optimize for a suitable choice for installation.

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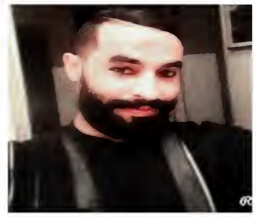

PhD student

Didi Faouzi Graduate: DEUA of University degree in Applied cold in 2008 Yahia Fares University of Médéa Algeria, State Engineer HVAC in 2011 from the University of khemis Miliana Algeria, academic Master in Energy and Thermal in 2012 University khemis Miliana Algeria in Mechanical Engineering Degree in 2014 of Yahia Fares University of Médéa Algeria, Master in Energy and Industrial Refrigeration in 2013 Yahia Fares University of Médéa Algeria, PhD in Physics specialty Renewable Energies during 201

Professor Doctor N. Bibi-Triki Graduate: State Engineer in mechanical engineering technology and industrial equipment of the University of Annaba Algeria, magister holder in physical energy and Doctorate of Science from the University Es Abu Bakr Belkaïd Tlemcen Algeria.

Professor, scientist, head of the National Research Project (NRP) in the field Agriculture, Food, Forestry, Natural and Rural Areas; head of research team in solar thermal material and thermal systems within the Research Unit of Materials and Renewable Energy (URMER) of the University of Tlemcen Algeria.